

FORMATION METHOD OF INSULATING FILM

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Abstract

PURPOSE: To obtain a formation method which forms an insulating film which can hold a high moisture absorption resistance even after a heat treatment or a treatment with a chemical liquid such as an amine-based organic solvent has been executed.

CONSTITUTION: An inorganic coating-type insulating film containing an Si-H bond, e.g. an inorganic SOG film 4, is formed by coating a semiconductor substrate 1. After that, an ashing treatment which uses O₂ ions as main reaction species is executed to its surface in an atmosphere under a pressure of 40Pa or lower.

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TITLE: Insulating film formation used in prodn. of high integration semiconductor device - carries out ashing processing of applied inorganic coating, in presence of oxygen ions and under pressure

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ABSTRACTED-PUB-NO: JP08316228A
BASIC-ABSTRACT:

The method carries out coating of SOG system inorganic material with Si-H coupling over the surface of a semiconductor substrate (1). This coating configures an insulating film (4).

Then, the insulating film is subjected to ashing processing using O₂ ions, under an environment whose pressure is maintained at 40pa or less.

ADVANTAGE - Enables waterproof insulating film to be formed. Prevents reduction in Si-H coupling.

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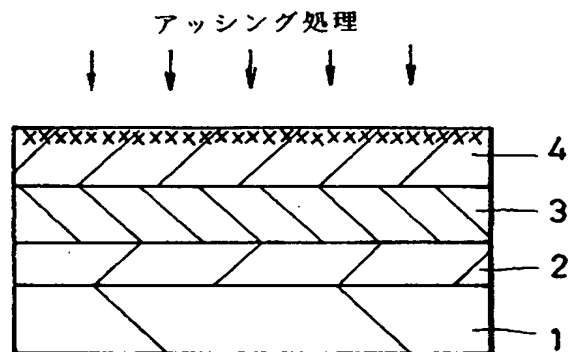
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(54) 【発明の名称】 絶縁膜の形成方法

(57) 【要約】

【目的】 熱処理やアミン系有機溶剤などの薬液による処理を行った後においても高い耐吸湿性が保持される絶縁膜を形成する。

【構成】 Si-H結合を含む無機系の塗布型絶縁膜、例えば無機SOG膜4を半導体基板1上に塗布形成した後、その表面に、圧力が40Pa以下の雰囲気中でO₂イオンを主反応種としたアッシング処理を施す。



【特許請求の範囲】

【請求項 1】 Si-H 結合を含む無機系の塗布型絶縁膜を基板上に形成した後、上記塗布型絶縁膜の表面に、圧力が 40 Pa 以下の雰囲気中で O₂ イオンを主反応種とした処理を施すようにしたことを特徴とする絶縁膜の形成方法。

【請求項 2】 上記塗布型絶縁膜の表面に、圧力が 6.6 ~ 13.3 Pa の雰囲気中で O₂ イオンを主反応種とした処理を施すようにしたことを特徴とする請求項 1 記載の絶縁膜の形成方法。

【請求項 3】 上記塗布型絶縁膜にコンタクトホールを形成した後、上記コンタクトホールの内壁に、圧力が 40 Pa 以下の雰囲気中で O₂ イオンを主反応種とした処理を施すようにしたことを特徴とする請求項 1 記載の絶縁膜の形成方法。

【請求項 4】 上記コンタクトホールの内壁に、圧力が 6.6 ~ 13.3 Pa の雰囲気中で O₂ イオンを主反応種とした処理を施すようにしたことを特徴とする請求項 3 記載の絶縁膜の形成方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】 この発明は、絶縁膜の形成方法に関し、例えば、多層配線構造の半導体装置における層間絶縁膜の形成に適用して好適なものである。

【0002】

【従来の技術】 近年、半導体装置の高集積化に伴い、配線の最小幅はサブミクロンに達し、また、配線の多層化も進んでいる。

【0003】 従来、半導体装置における配線パターンの形成は、薄膜形成技術、リソグラフィ技術およびエッチング技術を用いて行われているが、多層配線構造において微細な配線パターンを精度良く形成するためには、配線の下地表面の平坦化が不可欠である。

【0004】 すなわち、半導体装置の製造においては、シリコン (Si) 基板などの半導体基板上にトランジスタなどの素子を形成した後、その上に CVD 法により二酸化シリコン (SiO₂) 膜や窒化シリコン (SiN) 膜などの層間絶縁膜を形成し、この層間絶縁膜上に配線パターンを形成する。この CVD 法により形成される層間絶縁膜は、高密度であり、絶縁性能にも優れているものの、下地の半導体基板と相似形に形成されることから、その表面には半導体基板の表面の凹凸に対応する凹凸が現れる。このため、配線パターンを形成する前に、層間絶縁膜の表面を平坦化しておく必要がある。

【0005】 この表面平坦化の方法の一つとして、塗布型絶縁膜を層間絶縁膜として用い、この塗布型絶縁膜を凹凸のある半導体基板上に塗布する方法がある。この塗布型絶縁膜には、大別して、無機系のものと、有機系のものがある。このうち無機系の塗布型絶縁膜としては、シラノールを水やアルコールに溶解させた原料液を

半導体基板上にスピン塗布した後、熱処理を行うことにより容易にガラス化させることができるスピノングラス (Spin on Glass, SOG) 膜 (以下「無機 SOG 膜」という。) と呼ばれるものが良く知られている。

【0006】 この無機 SOG 膜は、表面平坦化を容易に行うことができる層間絶縁膜であるため、従来より広く用いられてきた。しかしながら、この無機 SOG 膜は、吸湿性が高く、多くの水分が膜中に含まれているため、層間絶縁膜として用いた場合には、次のような問題が生ずる。

【0007】 すなわち、半導体装置の製造においては、例えば、図 19 に示すように、半導体基板 101 上に層間絶縁膜 102 を介して形成された第 1 の配線 103 を覆うように層間絶縁膜として無機 SOG 膜 104 を全面にスピン塗布し、熱処理を行うことによりこの無機 SOG 膜 104 をガラス化させた後、この無機 SOG 膜 104 にエッチングによりコンタクトホール 105 を形成する。次に、このコンタクトホール 105 を通じて第 1 の配線 103 にコンタクトする第 2 の配線 106 を CVD 法やスパッタリング法により形成するが、この際に熱が加わって無機 SOG 膜 104 から水分が放出されることにより、コンタクトホール 105 の埋め込み不良 (例えば、ボイドの発生) や、無機 SOG 膜 104 に対する密着性の悪化による第 2 の配線 106 のはがれなどが生じる。

【0008】 これらの問題の解決を目的として、近年、シリコン (Si)-水素 (H) 結合を含ませることにより耐吸湿性を向上させた無機 SOG 膜が開発されている。このような Si-H 結合を含む無機 SOG 膜では、種々のプロセスを経た後にも、Si-H 結合をいかにして残すかが重要である。

【0009】

【発明が解決しようとする課題】 しかしながら、本発明者の知見によれば、Si-H 結合を含む無機 SOG 膜 104 を例えば 500℃ 以上の温度で熱処理したり、アミン系有機溶剤などに代表される洗浄液や現像液などの薬液により処理した場合には、熱の作用や薬液の触媒作用により、無機 SOG 膜 104 中の Si-H 結合が切断される反応が促進される。このため、無機 SOG 膜 104 中に含まれる Si-H 結合が減少し、結果的に耐吸湿性が悪化する。

【0010】 すなわち、図 19 に示すように、コンタクトホール 105 を形成する際に用いられるレジスト、現像液、洗浄液などが無機 SOG 膜 104 に接触することにより、この無機 SOG 膜 104 において Si-H 結合が切断される反応が生じ、その耐吸湿性が悪化してしまう。このため、コンタクトホール 105 の内部におけるボイドの発生や第 2 の配線 106 のはがれなどが起き、多層配線構造の信頼性を低下させていた。

【0011】 図 20 および図 21 は SOG 膜 104 の赤

外吸収スペクトルの測定結果の一例を示し、図 20 は塗布および熱処理後の測定結果、図 21 はアミン系有機洗浄液による洗浄後の測定結果を示す。図 20 および図 21 からわかるように、塗布および熱処理後の SOG 膜 104 の赤外吸収スペクトルには波数 2300 cm^{-1} 付近に Si-H 結合に起因する吸収ピークが観測されるが

(図 20)、アミン系有機洗浄液による洗浄後の SOG 膜 104 の赤外吸収スペクトルにはこの Si-H 結合に起因する吸収ピークは観測されない(図 21)。このことは、アミン系有機洗浄液による洗浄により SOG 膜 104 中の Si-H 結合がほとんど切断されてしまったことを示す。

【0012】したがって、この発明の目的は、熱処理やアミン系有機溶剤などの薬液による処理を行った後においても高い耐吸湿性が保持される絶縁膜を形成することができる絶縁膜の形成方法を提供することにある。

【0013】

【課題を解決するための手段】上記目的を達成するために、この発明による絶縁膜の形成方法は、Si-H 結合を含む無機系の塗布型絶縁膜を基板上に形成した後、塗布型絶縁膜の表面に、圧力が 40 Pa 以下の雰囲気中で O_2 イオンを主反応種とした処理を施すようにしたことを特徴とするものである。

【0014】この発明の一実施形態においては、塗布型絶縁膜にコンタクトホールを形成した後、コンタクトホールの内壁に、圧力が 40 Pa 以下の雰囲気中で O_2 イオンを主反応種とした処理を施す。

【0015】この発明において、 O_2 イオンを主反応種とした処理の雰囲気の圧力の上限は 40 Pa ($\approx 0.3\text{ Torr}$) 以下であるが、これは、 40 Pa を超える圧力では、 O_2 ラジカルが主反応種となり、塗布型絶縁膜の表面層の緻密化の効果が得られにくくなることや、塗布型絶縁膜にクラックが入りやすくなるなどの理由による。

【0016】この発明において、表面層の緻密化により塗布型絶縁膜の耐吸湿性を十分に高く保持し、しかもクラックなどが入るのをほぼ完全に防止するためには、 O_2 イオンを主反応種とした処理の雰囲気の圧力は、好適には、 $6.6\sim 13.3\text{ Pa}$ ($\approx 0.05\sim 0.1\text{ Torr}$) に選ばれる。

【0017】この発明において、 O_2 イオンを主反応種とした処理には、好適には、いわゆるホローカソード(hollow cathode)型のアッシング装置が用いられる。このホローカソード型のアッシング装置では、放電インピーダンスが小さいため、大きな放電電流が流れる。すなわち、プラズマの密度が非常に高く、被処理基板の表面に多量の O_2 イオンが入射する。この場合、この O_2 イオンのエネルギーは低いため、塗布型絶縁膜の表面層のみが緻密化される。

【0018】この発明において、 O_2 イオンを主反応種

とした処理には、ホローカソード型のアッシング装置に比べると O_2 イオン密度は一般に低い、平行平板型の反応性イオンエッチング(RIE)装置を用いてもよい。

【0019】

【作用】上述のように構成されたこの発明による絶縁膜の形成方法によれば、Si-H 結合を含む塗布型絶縁膜を基板上に形成した後、その塗布型絶縁膜の表面に、圧力が 40 Pa 以下の雰囲気中で O_2 イオンを主反応種とした処理を施すようにしていることにより、この塗布型絶縁膜の表面層を緻密化することができる。このため、その後熱処理やアミン系有機溶剤などの薬液による処理を行っても、塗布型絶縁膜中の Si-H 結合が切断される反応を抑制することができ、Si-H 結合の減少を防止することができる。これによって、塗布型絶縁膜の耐吸湿性を高く保持することができる。

【0020】

【実施例】以下、この発明の実施例について図面を参照しながら説明する。なお、実施例の全図において、同一または対応する部分には同一の符号を付す。

【0021】図 1～図 8 はこの発明の第 1 実施例による半導体装置の製造方法を工程順に示す断面図である。

【0022】この第 1 実施例による半導体装置の製造方法においては、まず、図 1 に示すように、あらかじめトランジスタなどの素子(図示せず)が形成された Si 基板のような半導体基板 1 上に層間絶縁膜 2 を介して第 1 の配線 3 を形成する。

【0023】次に、図 2 に示すように、第 1 の配線 3 を覆うように、Si-H 結合を含む無機 SOG 膜 4 を層間絶縁膜として全面にスピン塗布した後、熱処理を行うことによりこの無機 SOG 膜 4 をガラス化させる。この熱処理の温度は、無機 SOG 膜 4 中の Si-H 結合が切断されない温度、例えば 400°C 程度とする。

【0024】次に、図 3 に示すように、 O_2 イオンを主反応種としたアッシング処理を行うことにより、無機 SOG 膜 4 の表面層を緻密化する(このアッシング処理により緻密化した部分に「X」を付す。)。このアッシング処理は、ホローカソード型のアッシング装置により、 O_2 流量 100 SCCM 、RF 電力 200 W 、圧力 13.3 Pa ($\approx 0.1\text{ Torr}$) の条件で 1 分間行った。

【0025】図 9 に、この第 1 実施例において用いるホローカソード型のアッシング装置の一例を示す。図 9 において、符号 21 は真空容器を示す。この真空容器 21 は、真空排気口 21a に接続された真空排気系(図示せず)により真空排気されるようになっており、また、ガス導入口 21b からその内部に O_2 ガスが導入されるようになっている。この真空容器 21 内には、互いに対向して設けられた下側電極 22a およびメッシュ状の上側電極 22b からなるホローカソード 22 が設置されてい

る。このホローカソード 22 に RF 電力が印加される。被処理基板 23 は下側電極 22a 上に載置される。

【0026】次に、図 4 に示すように、リソグラフィにより無機 SOG 膜 4 上に所定形状のレジストパターン 5 を形成する。このレジストパターン 5 を形成する際には、無機 SOG 膜 4 の表面にレジスト、現像液、水などが接触し、Si-H 結合が切断される反応が生じるが、上述のように無機 SOG 膜 4 の表面層はアッシング処理によりあらかじめ緻密化されているため、この反応は抑制され、したがって無機 SOG 膜 4 の耐吸湿性は悪化しない。

【0027】次に、図 5 に示すように、レジストパターン 5 をマスクとして無機 SOG 膜 4 を、例えば、反応ガスとして C_2F_6 や CHF_3 を用いた RIE 法によりエッチングしてコンタクトホール 6 を形成する。

【0028】次に、上述と同様にして、図 9 に示すホローカソード型のアッシング装置により O_2 イオンを主反応種としたアッシング処理を施し、レジストパターン 5 を除去するとともに、コンタクトホール 6 の内壁の無機 SOG 膜 4 の表面層を緻密化する。この後、レジスト残渣やポリマーの除去などを目的として、アミン系有機溶剤などを用いて洗浄を行う。この洗浄時には、アミン系有機溶剤などがコンタクトホール 6 の内壁の無機 SOG 膜 4 に接触するが、このコンタクトホール 6 の内壁の無機 SOG 膜 4 の表面層は上述のようにアッシング処理によりあらかじめ緻密化されているため、Si-H 結合が切断される反応は抑制され、耐吸湿性は悪化しない。

【0029】次に、図 8 に示すように、コンタクトホール 6 を通じて第 1 の配線 3 にコンタクトする第 2 の配線 7 を CVD 法やスパッタリング法により形成する。この第 2 の配線 7 を形成する際には、熱が加わる場合がほとんどであるが、上述のように無機 SOG 膜 4 の耐吸湿性は悪化していないため、この無機 SOG 膜 4 から水分に代表されるようなガスの放出はなく、コンタクトホール 6 の内部におけるボイドの発生や第 2 の配線 7 のはがれなどの不良は生じない。

【0030】図 10、図 11 および図 12 は無機 SOG 膜 4 の赤外吸収スペクトルの測定結果の一例を示し、それぞれ、無機 SOG 膜 4 の塗布および熱処理後の測定結果、アッシング処理後の測定結果およびアミン系有機洗浄液による洗浄後の測定結果を示す。

【0031】図 10、図 11 および図 12 からわかるように、Si-H 結合に起因する波数 2300 cm^{-1} 付近の吸収ピークは、無機 SOG 膜 4 の塗布および熱処理後、アッシング処理後およびアミン系有機洗浄液による洗浄後のいずれにおいても同様に観測される。これは、これらのプロセスを経た後においても、無機 SOG 膜 4 中の Si-H 結合が減少していないことを示す。

【0032】以上のように、この第 1 実施例によれば、Si-H 結合を含む無機 SOG 膜 4 の表面およびコンタ

クトホール 6 の内壁に、圧力が 40 Pa 以下、例えば 13.3 Pa の雰囲気中で O_2 イオンを主反応種としたアッシング処理を行っているので、この無機 SOG 膜 4 の表面層およびコンタクトホール 6 の内壁の無機 SOG 膜 4 の表面層を緻密化することができる。このため、後に熱処理やアミン系有機溶剤などの薬液による処理を行っても、無機 SOG 膜 4 中の Si-H 結合が切断されて減少するのを防止することができ、この無機 SOG 膜 4 の耐吸湿性を高く保持することができる。これによって、この無機 SOG 膜 4 からの水分などのガスの放出に起因するコンタクトホール 6 の内部におけるボイドの発生や第 2 の配線 7 のはがれなどを防止することができ、信頼性の高い多層配線構造を実現することができる。

【0033】次に、この発明の第 2 実施例について説明する。

【0034】図 13～図 18 はこの発明の第 2 実施例による半導体装置の製造方法を工程順に示す断面図である。

【0035】この第 2 実施例による半導体装置の製造方法においては、まず、図 13 に示すように、第 1 実施例による半導体装置の製造方法と同様に、半導体基板 1 上に層間絶縁膜 2 を介して形成された第 1 の配線 3 を覆うように層間絶縁膜 8 を形成する。この層間絶縁膜 8 としては、TEOS ($Si(OC_2H_5)_4$) を反応ガスとしたプラズマ CVD 法により形成された SiO_2 膜や、シラン (SiH_4) を反応ガスとしたプラズマ CVD 法により形成された SiO_2 膜が好適に用いられる。この層間絶縁膜 8 は、後述の無機 SOG 膜 4 を薬液などから保護したり、この無機 SOG 膜 4 の下地に対する密着性の向上を図るためなどの理由により形成される。

【0036】次に、図 14 に示すように、Si-H 結合を含む無機 SOG 膜 4 を全面にスピン塗布した後、熱処理を行うことによりこの無機 SOG 膜 4 をガラス化させる。次に、この無機 SOG 膜 4 上に層間絶縁膜 9 を形成する。この層間絶縁膜 9 としては、層間絶縁膜 8 と同様に、TEOS ($Si(OC_2H_5)_4$) を反応ガスとしたプラズマ CVD 法により形成された SiO_2 膜や SiH_4 を反応ガスとしたプラズマ CVD 法により形成された SiO_2 膜が好適に用いられる。この層間絶縁膜 8 は、後述の無機 SOG 膜 4 を薬液などから保護したり、後述の第 2 の配線 7 の下地に対する密着性の向上を図るためなどの理由により形成される。

【0037】次に、図 15 に示すように、リソグラフィにより層間絶縁膜 9 上に所定形状のレジストパターン 5 を形成する。この場合、無機 SOG 膜 4 の上下に CVD 法により形成された層間絶縁膜 8、9 が存在するため、Si-H 結合が切断される反応を引き起こすレジスト、現像液などの薬液が無機 SOG 膜 4 に接触するのを避けることができ、したがって無機 SOG 膜 4 の耐吸湿性は悪化しない。

【0038】次に、図16に示すように、レジストパターン5をマスクとして、層間絶縁膜9、無機SOG膜4および層間絶縁膜8を、例えば、反応ガスとして C_2F_6 や CHF_3 を用いたRIE法により順次エッチングしてコンタクトホール6を形成する。

【0039】次に、図17に示すように、第1実施例と同様にして、図9に示すホローカソード型のアッシング装置により、 O_2 イオンを主反応種としたアッシング処理を施し、レジストパターン5を除去するとともに、コンタクトホール6の内壁の無機SOG膜4の表面層を緻密化する（このアッシング処理により緻密化した部分に「X」を付す。）。このアッシング処理は、 O_2 流量100SCCM、RF電力200W、圧力13.3Pa（ ≈ 0.1 Torr）の条件で1分間行った。その後、レジスト残渣やポリマーの除去を目的として、アミン系有機溶剤などの洗浄液を用いて洗浄を行う。この洗浄時には、洗浄液がコンタクトホール6の内壁の無機SOG膜4に接触しても、この内壁の無機SOG膜4の表面層は上述のようにアッシング処理によりあらかじめ緻密化されているので、Si-H結合が切断される反応は抑制され、無機SOG膜4の耐吸湿性は悪化しない。

【0040】次に、図18に示すように、コンタクトホール6を通じて第1の配線3にコンタクトする第2の配線7をCVD法やスパッタリング法により形成する。この第2の配線7を形成する際には、高温が加わる場合がほとんどであるが、上述のように無機SOG膜4の耐吸湿性は悪化していないため、無機SOG膜4から水分に代表されるようなガスの放出はなく、したがってコンタクトホール6の内部におけるボイドの発生や第2の配線7のはがれなどの不良は生じない。

【0041】以上のように、この第2実施例によれば、無機SOG膜4の上下にCVD法により層間絶縁膜8、9を形成していることにより、後のプロセスにおいてレジストや現像液などの薬液が無機SOG膜4に接触するのを避けることができ、したがってこれらの薬液がこの無機SOG膜4に接触することによる耐吸湿性の悪化を防止することができる。また、第1実施例と同様に、無機SOG膜4にコンタクトホール6を形成した後、このコンタクトホール6の内壁に O_2 イオンを主反応種としたアッシング処理を行っているため、このコンタクトホール6の内壁の無機SOG膜4の表面層を緻密化することができ、無機SOG膜4の耐吸湿性を高く保持することができる。これによって、この無機SOG膜4からの水分などのガスの放出に起因するコンタクトホール6の内部におけるボイドの発生や第2の配線7のはがれなどを防止することができる。以上により、信頼性の高い多層配線構造を実現することができる。

【0042】以上、この発明の実施例について具体的に説明したが、この発明は、上述の実施例に限定されるものではなく、この発明の技術的思想に基づく各種の変形

が可能である。

【0043】例えば、上述の第1実施例および第2実施例においては、Si-H結合を含む無機系の塗布型絶縁膜として、Si-H結合を含む無機SOG膜4を用いているが、Si-H結合を含む無機系絶縁膜であれば、無機SOG膜4以外のものを用いてもよい。

【0044】

【発明の効果】以上説明したように、この発明によれば、Si-H結合を含む無機系の塗布型絶縁膜を基板上に形成した後、塗布型絶縁膜の表面に、圧力が40Pa以下の雰囲気中で O_2 イオンを主反応種とした処理を施すようにしていることにより、塗布型絶縁膜の表面層を緻密化することができ、このため後に熱処理やアミン系有機溶剤などの薬液による処理を行った後においても、塗布型絶縁膜中のSi-H結合の減少を防止することができ、塗布型絶縁膜の耐吸湿性を高く保持することができる。

【図面の簡単な説明】

【図1】この発明の第1実施例による半導体装置の製造方法を説明するための断面図である。

【図2】この発明の第1実施例による半導体装置の製造方法を説明するための断面図である。

【図3】この発明の第1実施例による半導体装置の製造方法を説明するための断面図である。

【図4】この発明の第1実施例による半導体装置の製造方法を説明するための断面図である。

【図5】この発明の第1実施例による半導体装置の製造方法を説明するための断面図である。

【図6】この発明の第1実施例による半導体装置の製造方法を説明するための断面図である。

【図7】この発明の第1実施例による半導体装置の製造方法を説明するための断面図である。

【図8】この発明の第1実施例による半導体装置の製造方法を説明するための断面図である。

【図9】この発明の第1実施例による半導体装置の製造方法においてアッシング処理に用いるホローカソード型のアッシング装置の一例を示す略線図である。

【図10】この発明の第1実施例による半導体装置の製造方法において塗布および熱処理を行った後の無機SOG膜の赤外吸収スペクトルの測定結果の一例を示すグラフである。

【図11】この発明の第1実施例による半導体装置の製造方法においてアッシング処理を行った後の無機SOG膜の赤外吸収スペクトルの測定結果の一例を示すグラフである。

【図12】この発明の第1実施例による半導体装置の製造方法においてアミン系有機洗浄液による洗浄を行った後の無機SOG膜の赤外吸収スペクトルの測定結果の一例を示すグラフである。

【図13】この発明の第2実施例による半導体装置の製

造方法を説明するための断面図である。

【図 1 4】この発明の第 2 実施例による半導体装置の製造方法を説明するための断面図である。

【図 1 5】この発明の第 2 実施例による半導体装置の製造方法を説明するための断面図である。

【図 1 6】この発明の第 2 実施例による半導体装置の製造方法を説明するための断面図である。

【図 1 7】この発明の第 2 実施例による半導体装置の製造方法を説明するための断面図である。

【図 1 8】この発明の第 2 実施例による半導体装置の製造方法を説明するための断面図である。

【図 1 9】従来の半導体装置の製造方法を説明するための断面図である。

【図 2 0】従来の半導体装置の製造方法において塗布お

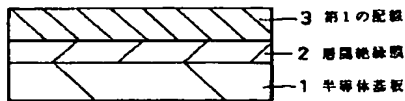
よび熱処理を行った後の無機 SOG 膜の赤外吸収スペクトルの測定結果の一例を示すグラフである。

【図 2 1】従来の半導体装置の製造方法においてアミン系有機洗浄液による洗浄を行った後の無機 SOG 膜の赤外吸収スペクトルの測定結果の一例を示すグラフである。

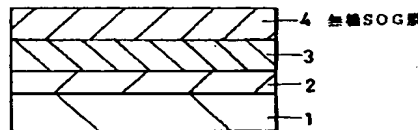
【符号の説明】

- 1 半導体基板
- 2、8、9 層間絶縁膜
- 3 第 1 の配線
- 4 無機 SOG 膜
- 6 コンタクトホール
- 7 第 2 の配線

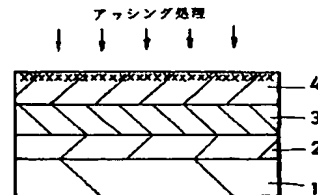
【図 1】



【図 2】

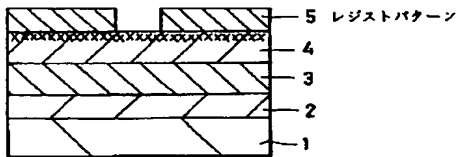


【図 3】

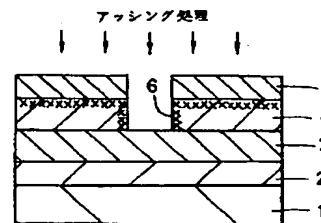


【図 4】

【図 5】

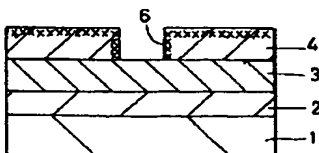


【図 6】

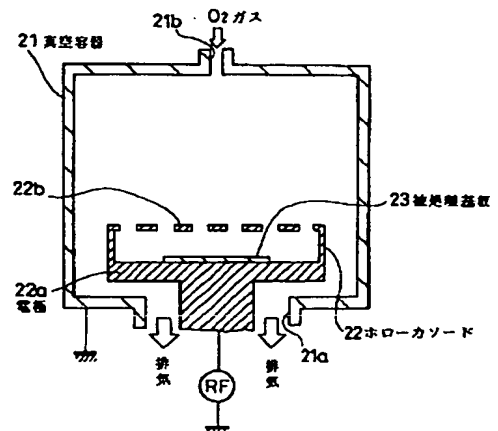


【図 7】

【図 8】

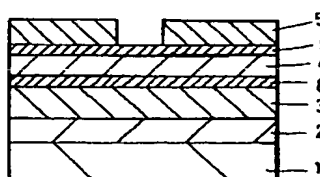
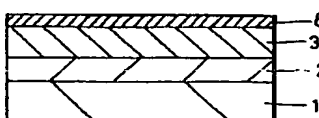


【図 9】

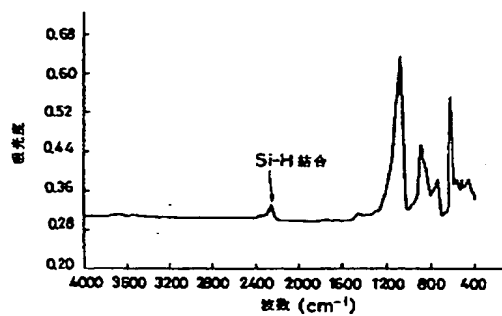


【図 1 3】

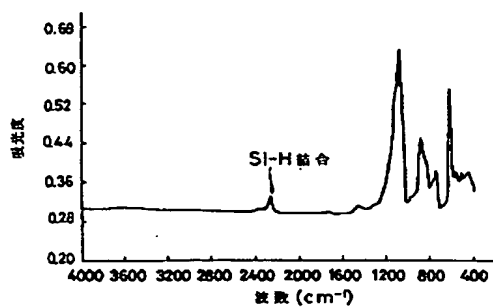
【図 1 4】



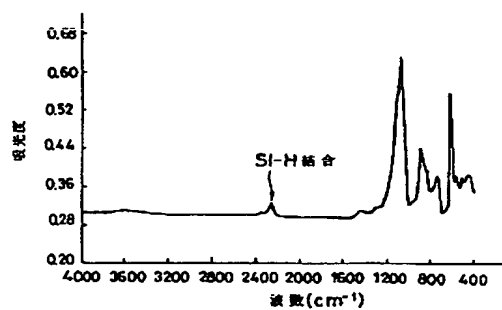
【図10】



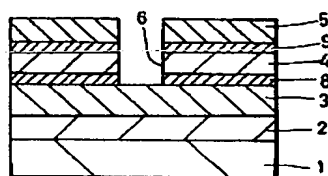
【図11】



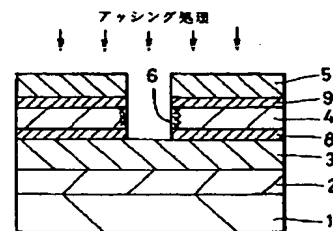
【図12】



【図15】

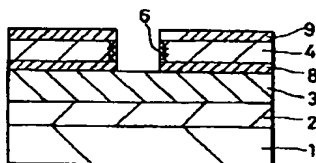


【図16】

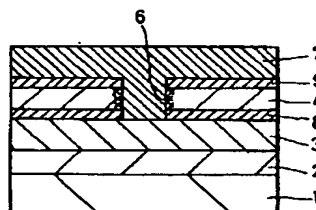


【図19】

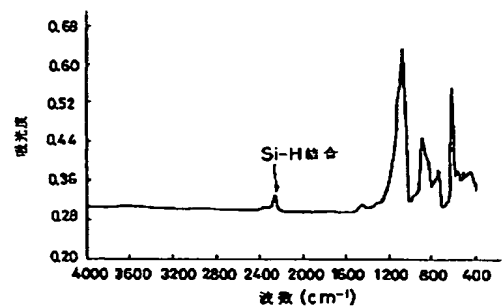
【図17】



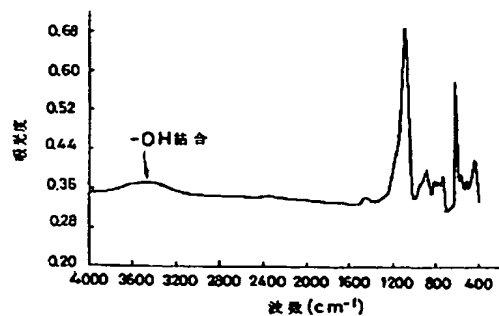
【図18】



【図20】



【図21】



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3. In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] A pressure is O₂ in the ambient atmosphere 40Pa or less to the front face of the applied type insulator layer above-mentioned after forming the applied type insulator layer of the inorganic system containing Si-H coupling on a substrate. The formation technique of the insulator layer characterized by performing processing which used ion as the main-reaction kind.

[Claim 2] It is O₂ in the ambient atmosphere whose pressure is 6.6-13.3Pa on the front face of the above-mentioned applied type insulator layer. The formation technique of the insulator layer according to claim 1 characterized by performing processing which used ion as the main-reaction kind.

[Claim 3] A pressure is O₂ in the ambient atmosphere 40Pa or less to the wall of the contact hole above-mentioned after forming a contact hole in the above-mentioned applied type insulator layer. The formation technique of the insulator layer according to claim 1 characterized by performing processing which used ion as the main-reaction kind.

[Claim 4] It is O₂ in the ambient atmosphere whose pressure is 6.6-13.3Pa at the wall of the above-mentioned contact hole. The formation technique of the insulator layer according to claim 3 characterized by performing processing which used ion as the main-reaction kind.

[Translation done.]

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3. In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention is applied to formation of the layer insulation layer in the semiconductor device of multilayer-interconnection structure, concerning the formation technique of an insulator layer, and is suitable.

[0002]

[Description of the Prior Art] In recent years, in connection with high integration of a semiconductor device, the minimum width of face of a wiring reaches submicron one, and multilayering of a wiring is also progressing.

[0003] Although formation of the wiring pattern in a semiconductor device is conventionally performed using a thin film coating technology, lithography technique, and etching technique, in order to form a detailed wiring pattern with a sufficient precision in multilayer-interconnection structure, the flattening on the front face of a substratum of a wiring is indispensable.

[0004] That is, in a manufacture of a semiconductor device, after forming elements, such as a transistor, in semiconductor substrates, such as a silicon (Si) substrate, layer insulation layers, such as a diacid-ized silicon (SiO₂) layer and a silicon-nitride (SiN) layer, are formed by CVD on it, and a wiring pattern is formed on this layer insulation layer. Although the layer insulation layer formed of this CVD is high-density and being excelled also in the insulating performance, since it is formed in the semiconductor substrate and analog of a substratum, in the front face, the irregularity corresponding to the irregularity of the front face of a semiconductor substrate appears. For this reason, before forming a wiring pattern, it is necessary to carry out the flattening of the front face of a layer insulation layer.

[0005] There is the technique of applying this applied type insulator layer on an irregular semiconductor substrate as one of the technique of this surface flattening, using an applied type insulator layer as a layer insulation layer. It divides roughly into this applied type insulator layer, and there are a thing of an inorganic system and a thing of an organic system in it. Among these, after carrying out the spin application of the raw material liquid made to melt a silanol in water or alcohol on a semiconductor substrate as an applied type insulator layer of an inorganic system, what is called spin-on glass (Spin ON Glass, SOG) layer (henceforth "inorganic SOG layer") which can be made to vitrify easily is well known by performing heat treatment.

[0006] Since it is the layer insulation layer which can perform a surface flattening easily, this inorganic SOG layer has been used more widely than the former. However, this inorganic SOG layer has high hygroscopicity, and since many moisture is contained in the layer, when it uses as a layer insulation layer, the following problems produce it.

[0007] That is, in a manufacture of a semiconductor device, as shown in drawing 19, the spin application of the inorganic SOG layer 104 is carried out as a layer insulation layer on the whole surface so that the 1st wiring 103 formed through the layer insulation layer 102 on the semiconductor substrate 101 may be covered, and after making this inorganic SOG layer 104 vitrify by heat-treating, the contact hole 105 is formed in this inorganic SOG layer 104 by etching, for example. Next, although the 2nd wiring 106 which contacts the 1st wiring 103 through this contact hole 105 is formed by CVD or the sputtering method, poor embedding of the contact hole 105 (for example, occurrence of a void), peeling of the 2nd wiring 106 by aggravation of the adhesion to the inorganic SOG layer 104, etc. arise by applying heat in this case and emitting moisture to it from the inorganic SOG layer 104.

[0008] Inorganic SOG layer which raised hygroscopicity-proof is developed by including silicon (Si)-hydrogen (H) combination for the purpose of a resolution of these problems in recent years. After passing through various processes by inorganic SOG layer containing such Si-H coupling, it is important how it leaves Si-H coupling.

[0009]

[Problem(s) to be Solved by the Invention] However, when according to this invention person's knowledge the inorganic SOG layer 104 containing Si-H coupling is heat-treated at the temperature of 500 degrees C or more or it processes with the medical fluids represented by the amine system organic solvent etc., such as a penetrant remover and a developer, the reaction from which Si-H coupling in the inorganic SOG layer 104 is cut is promoted by an operation of heat and the catalysis of a medical fluid. For this reason, Si-H coupling contained in the inorganic SOG layer 104 decreases, and hygroscopicity-proof gets worse as a result.

[0010] That is, when the resist and developer which are used in case the contact hole 105 is formed, as shown in drawing 19, a penetrant remover, etc. contact the inorganic SOG layer 104, the reaction from which Si-H coupling is cut in this inorganic SOG layer 104 will arise, and the hygroscopicity-proof will get worse. For this reason, occurrence of the void in the interior of the contact hole 105, peeling of the 2nd wiring 106, etc. occurred, and the reliability of multilayer-interconnection structure was reduced.

[0011] The measurement result after washing according [accord / the measurement result after an application and heat treatment / drawing 20 / the drawing 20 and the drawing 21 show an example of the measurement result of the infrared absorption spectrum of the SOG layer 104, and / drawing 21] to an amine system organic penetrant remover is shown. Although the absorption peak which originates in the wave number [of 2300cm]-1 neighborhood at Si-H coupling is observed by the infrared absorption spectrum of the SOG layer 104 after an application and heat treatment as shown in the drawing 20 and the drawing 21 (drawing 20), the absorption peak resulting from this Si-H coupling is not observed by the infrared absorption spectrum of the SOG layer 104 after washing by the amine system organic penetrant remover (drawing 21). This shows that Si-H coupling in the SOG layer 104 has almost been cut by washing by the amine system organic penetrant remover.

[0012] Therefore, the purpose of this invention is to offer the formation technique of the insulator layer which can form the insulator layer by which high hygroscopicity-proof is held, after performing processing by medical fluids, such as heat treatment and an amine system organic solvent.

[0013]

[Means for Solving the Problem] For the formation technique of the insulator layer according to this invention in order to attain the above-mentioned purpose, a pressure is O2 in the ambient atmosphere 40Pa or less to the front face of an application type insulator layer after forming the applied type insulator layer of the inorganic system containing Si-H coupling on a substrate. It is characterized by performing processing which used ion as the main-reaction kind.

[0014] A pressure is O2 in the ambient atmosphere 40Pa or less to the wall of a contact hole after forming a contact hole in an applied type insulator layer in the 1 operation gestalt of this invention. Processing which used ion as the main-reaction kind is performed.

[0015] It sets to this invention and is O2. At the pressure by which this exceeds 40Pa although the upper limit of the pressure of the ambient atmosphere of processing which used ion as the main-reaction kind is below 40Pa (**0.3Torr), it is O2. It is based on that a radical serves as a main-reaction kind and the effect of precise-izing of the surface layer of an applied type insulator layer becomes is hard to be acquired, and the grounds, -- a crack becomes easy to go into an applied type insulator layer

[0016] It is O2 in order to prevent nearly completely that hold the hygroscopicity-proof of an applied type insulator layer enough highly by precise-ization of a surface layer, and a crack etc. moreover enters in this invention. The pressure of the ambient atmosphere of processing which used ion as the main-reaction kind is suitably chosen as 6.6-13.3Pa (**0.05 - 0.1Torr).

[0017] It sets to this invention and is O2. In processing which used ion as the main-reaction kind, it is the so-called hollow cathode (hollow cathode) suitably. The ashing equipment of type is used. For a parvus reason, the big discharge current flows [an electric discharge impedance] with this hollow cathode type ashing equipment. That is, the density of a plasma is very high and it is a lot of O2 on the front face of a processed substrate. Ion carries out incidence. In this case, these O2 Since the energy of ion is low, only the surface layer of an applied type insulator layer is made precise.

[0018] It sets to this invention and is O2. Compared with the ashing equipment of a hollow cathode type [processing / which used ion as the main-reaction kind], it is O2. Although ion density is generally low, you may use parallel monotonous type reactive-ion-etching (RIE) equipment.

[0019]

[Function] A pressure is O2 in the ambient atmosphere 40Pa or less to the front face of the application type insulator layer after forming the applied type insulator layer containing Si-H coupling on a substrate according to the formation technique of the insulator layer by this invention constituted as mentioned above. By being made to perform processing which used ion as the main-reaction kind, the surface layer of this applied type insulator layer can be made precise. For this reason, even if it performs processing by medical fluids, such as heat treatment and an amine system organic solvent, after that, the reaction from which Si-H coupling in an applied type insulator layer is cut can be suppressed, and a decrement of Si-H coupling can be prevented. By this, the hygroscopicity-proof of an applied type insulator layer can be held highly.

[0020]

[Example] Hereafter, it explains, referring to a drawing about the example of this invention. In addition, in the complete-diagram of an example, the same sign is given to an identity or a corresponding fraction.

[0021] Drawing 1 - view 8 is the cross section showing the manufacture technique of the semiconductor device by the 1st example of this invention in the order of a process.

[0022] In the manufacture technique of the semiconductor device by this 1st example, first, as shown in drawing 1 , the 1st wiring 3 is formed through the layer insulation layer 2 on a semiconductor substrate 1 like Si substrate in which elements (not shown), such as a transistor, were formed beforehand.

[0023] Next, after carrying out a spin application on the whole surface, using the inorganic SOG layer 4 containing Si-H coupling as a layer insulation layer so that the 1st wiring 3 may be covered as shown in drawing 2 , this inorganic SOG layer 4 is made to vitrify by performing heat treatment. Temperature of this heat treatment is made into the about temperature from which Si-H coupling in the inorganic SOG layer 4 is not cut, for example, 400 degrees C.

[0024] Next, it is O2 as shown in drawing 3 . By performing ashing processing which used ion as the main-reaction kind, the surface layer of the inorganic SOG layer 4 is made precise ("x" is given to the fraction made precise by this ashing processing.). This ashing processing is O2 by hollow cathode type ashing equipment. It carried out for 1 minute on flow rate 100SCCM, RF power 200W, and conditions with a pressure of 13.3Pa (**0.1Torr).

[0025] An example of the hollow cathode type ashing equipment used for drawing 9 in this 1st example is shown. In drawing 9 , a sign 21 shows a vacuum housing. Evacuation is carried out by the evacuation system (not shown) connected to evacuation

opening 21a, and this vacuum housing 21 is O₂ from gas inlet 21b to the interior. Gas introduces. In this vacuum housing 21, the hollow cathode 22 which consists of the top electrode 22b of the shape of bottom electrode 22a and a mesh which counters mutually and was established is installed. RF power is impressed to this hollow cathode 22. The processed substrate 23 is laid on bottom electrode 22a.

[0026] Next, as shown in drawing 4, the resist pattern 5 of a predetermined configuration is formed on the inorganic SOG layer 4 with lithography. In case this resist pattern 5 is formed, although the reaction from which a resist, a developer, water, etc. contact the front face of the inorganic SOG layer 4, and Si-H coupling is cut arises, since the surface layer of the inorganic SOG layer 4 is beforehand made precise by ashing processing as mentioned above, this reaction is suppressed, therefore the hygroscopicity-proof of the inorganic SOG layer 4 does not get worse.

[0027] Next, it is C₂F₆ considering the inorganic SOG layer 4 as reactant gas, using the resist pattern 5 as a mask, as shown in drawing 5. CHF₃ It etches by the used RIE method and the contact hole 6 is formed.

[0028] Next, it is O₂ by the hollow cathode type ashing equipment shown in drawing 9 like ****. While ashing processing which used ion as the main-reaction kind is performed and the resist pattern 5 is removed, the surface layer of the inorganic SOG layer 4 of the wall of the contact hole 6 is made precise. Then, it washes for the purpose of a resist residue, elimination of a polymer, etc. using the amine system organic solvent etc. At the time of this washing, although the amine system organic solvent etc. contacts the inorganic SOG layer 4 of the wall of the contact hole 6, since the surface layer of the inorganic SOG layer 4 of the wall of this contact hole 6 is beforehand made precise by ashing processing as mentioned above, the reaction from which Si-H coupling is cut is suppressed and hygroscopicity-proof does not get worse.

[0029] Next, as shown in drawing 8, the 2nd wiring 7 which contacts the 1st wiring 3 through the contact hole 6 is formed by CVD or the sputtering method. As mentioned above, although the case where heat is applied is most in case this 2nd wiring 7 is formed, since the hygroscopicity-proof of the inorganic SOG layer 4 is not getting worse, there is no exudation of gas which is represented by moisture from this inorganic SOG layer 4, and the failures in the interior of the contact hole 6, such as occurrence of a void and peeling of the 2nd wiring 7, are not produced.

[0030] Drawing 10, the drawing 11, and the drawing 12 show an example of the measurement result of the infrared absorption spectrum of the inorganic SOG layer 4, and show an application of the inorganic SOG layer 4 and the measurement result after heat treatment, the measurement result after ashing processing, and the measurement result after washing by the amine system organic penetrant remover, respectively.

[0031] As shown in drawing 10, the drawing 11, and the drawing 12, the absorption peak of the wave number [of 2300cm⁻¹]-1 neighborhood resulting from Si-H coupling is similarly observed in any after washing after an application and heat treatment of the inorganic SOG layer 4, and ashing processing and by the amine system organic penetrant remover. This shows that Si-H coupling in the inorganic SOG layer 4 is not decreasing, after passing through these processes.

[0032] As mentioned above, it is O₂ in the ambient atmosphere whose pressure is 40Pa or less, for example, 13.3Pa, at the wall of the front face of the inorganic SOG layer 4 containing Si-H coupling, and the contact hole 6 according to this 1st example. Since ashing processing which used ion as the main-reaction kind is performed, the surface layer of this inorganic SOG layer 4 and the surface layer of the inorganic SOG layer 4 of the wall of the contact hole 6 can be made precise. For this reason, even if it performs processing by medical fluids, such as heat treatment and an amine system organic solvent, behind, it can prevent Si-H coupling in the inorganic SOG layer 4 being cut, and decreasing, and the hygroscopicity-proof of this inorganic SOG layer 4 can be held highly. By this, occurrence of the void in the interior of the contact hole 6 resulting from exudation of gas, such as moisture from this inorganic SOG layer 4, peeling of the 2nd wiring 7, etc. can be prevented, and reliable multilayer-interconnection structure can be realized.

[0033] Next, the 2nd example of this invention is explained.

[0034] Drawing 13 - view 18 is the cross section showing the manufacture technique of the semiconductor device by the 2nd example of this invention in the order of a process.

[0035] In the manufacture technique of the semiconductor device by this 2nd example, first, as shown in drawing 13, the layer insulation layer 8 is formed like the manufacture technique of the semiconductor device by the 1st example, so that the 1st wiring 3 formed through the layer insulation layer 2 on the semiconductor substrate 1 may be covered. It is SiO₂ formed as this layer insulation layer 8 by the plasma CVD method which made reactant gas TEOS (Si₄ (OC₂ H₅)). SiO₂ formed by the layer and the plasma CVD method which made the silane (SiH₄) reactant gas A layer is used suitably. This layer insulation layer 8 protects the below-mentioned inorganic SOG layer 4 from a medical fluid etc., or is formed of the ground for aiming at enhancement of adhesion to the substratum of this inorganic SOG layer 4 etc.

[0036] Next, as shown in drawing 14, after carrying out the spin application of the inorganic SOG layer 4 containing Si-H coupling on the whole surface, this inorganic SOG layer 4 is made to vitrify by performing heat treatment. Next, the layer insulation layer 9 is formed on this inorganic SOG layer 4. It is SiO₂ formed like the layer insulation layer 8 as this layer insulation layer 9 by the plasma CVD method which made reactant gas TEOS (Si₄ (OC₂ H₅)). A layer and SiH₄ SiO₂ formed by the plasma CVD method made into reactant gas A layer is used suitably. This layer insulation layer 8 protects the below-mentioned inorganic SOG layer 4 from a medical fluid etc., or is formed of the ground for aiming at enhancement of adhesion to the substratum of the 2nd below-mentioned wiring 7 etc.

[0037] Next, as shown in drawing 15, the resist pattern 5 of a predetermined configuration is formed on the layer insulation layer 9 with lithography. In this case, since the layer insulation layers 8 and 9 formed in the upper and lower sides of the inorganic SOG layer 4 of CVD exist, it can avoid that the medical fluids which trigger the reaction from which Si-H coupling is cut, such as a

resist and a developer, contact the inorganic SOG layer 4, therefore the hygroscopicity-proof of the inorganic SOG layer 4 does not get worse.

[0038] Next, it is C2 F6 considering the layer insulation layer 9, the inorganic SOG layer 4, and the layer insulation layer 8 as reactant gas, using the resist pattern 5 as a mask, as shown in drawing 16. CHF3 It etches one by one by the used RIE method, and the contact hole 6 is formed.

[0039] Next, it is O2 by the hollow cathode type ashing equipment shown in drawing 9 like the 1st example as shown in drawing 17. While ashing processing which used ion as the main-reaction kind is performed and the resist pattern 5 is removed, the surface layer of the inorganic SOG layer 4 of the wall of the contact hole 6 is made precise ("x" is given to the fraction made precise by this ashing processing.). This ashing processing is O2. It carried out for 1 minute on flow rate 100SCCM, RF power 200W, and conditions with a pressure of 13.3Pa (**0.1 Torr). Then, it washes for the purpose of elimination of a resist residue or a polymer using penetrant removers, such as an amine system organic solvent. At the time of this washing, even if a penetrant remover contacts the inorganic SOG layer 4 of the wall of the contact hole 6, since the surface layer of the inorganic SOG layer 4 of this wall is beforehand made precise by ashing processing as mentioned above, the reaction from which Si-H coupling is cut is suppressed and the hygroscopicity-proof of the inorganic SOG layer 4 does not get worse.

[0040] Next, as shown in drawing 18, the 2nd wiring 7 which contacts the 1st wiring 3 through the contact hole 6 is formed by CVD or the sputtering method. As mentioned above, although the case where an elevated temperature is applied is most in case this 2nd wiring 7 is formed, since the hygroscopicity-proof of the inorganic SOG layer 4 is not getting worse, there is no exudation of gas which is represented by moisture from the inorganic SOG layer 4, therefore the failures in the interior of the contact hole 6, such as occurrence of a void and peeling of the 2nd wiring 7, are not produced.

[0041] As mentioned above, according to this 2nd example, the aggravation of hygroscopicity-proof by being able to avoid that medical fluids, such as a resist and a developer, contact the inorganic SOG layer 4 in a next process, therefore these medical fluids contacting this inorganic SOG layer 4 can be prevented by forming the layer insulation layers 8 and 9 in the upper and lower sides of the inorganic SOG layer 4 by CVD. Moreover, it is O2 to the wall of this contact hole 6 after forming the contact hole 6 in the inorganic SOG layer 4 like the 1st example. Since ashing processing which used ion as the main-reaction kind is performed, the surface layer of the inorganic SOG layer 4 of the wall of this contact hole 6 can be made precise, and the hygroscopicity-proof of the inorganic SOG layer 4 can be held highly. By this, occurrence of the void in the interior of the contact hole 6 resulting from exudation of gas, such as moisture from this inorganic SOG layer 4, peeling of the 2nd wiring 7, etc. can be prevented. Reliable multilayer-interconnection structure is realizable with the above.

[0042] As mentioned above, although the example of this invention was explained concretely, this invention is not limited to an above-mentioned example, and various kinds of deformation based on the technical thought of this invention is possible for it.

[0043] For example, in the 1st above-mentioned example and the 2nd example, although the inorganic SOG layer 4 containing Si-H coupling is used as an applied type insulator layer of the inorganic system containing Si-H coupling, as long as it is an inorganic system insulator layer containing Si-H coupling, you may use things other than inorganic SOG layer 4.

[0044]

[Effect of the Invention] As explained above, after forming the applied type insulator layer of the inorganic system containing Si-H coupling on a substrate according to this invention, To the front face of an applied type insulator layer, a pressure is O2 in the ambient atmosphere 40Pa or less. By being made to perform processing which used ion as the main-reaction kind The surface layer of an applied type insulator layer can be made precise, after performing processing by medical fluids, such as heat treatment and an amine system organic solvent, behind for this reason, a decrement of Si-H coupling in an applied type insulator layer can be prevented, and the hygroscopicity-proof of an applied type insulator layer can be held highly.

[Translation done.]

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Field

[Field of the Invention] This invention is applied to formation of the layer insulation layer in the semiconductor device of multilayer-interconnection structure, concerning the formation technique of an insulator layer, and is suitable.

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Technique

[Description of the Prior Art] In recent years, in connection with high integration of a semiconductor device, the minimum width of face of a wiring reaches submicron one, and multilayering of a wiring is also progressing.

[0003] Although formation of the wiring pattern in a semiconductor device is conventionally performed using a thin film coating technology, lithography technique, and etching technique, in order to form a detailed wiring pattern with a sufficient precision in multilayer-interconnection structure, the flattening on the front face of a substratum of a wiring is indispensable.

[0004] That is, in a manufacture of a semiconductor device, after forming elements, such as a transistor, in semiconductor substrates, such as a silicon (Si) substrate, layer insulation layers, such as a diacid-ized silicon (SiO₂) layer and a silicon-nitride (SiN) layer, are formed by CVD on it, and a wiring pattern is formed on this layer insulation layer. Although the layer insulation layer formed of this CVD is high-density and being excelled also in the insulating performance, since it is formed in the semiconductor substrate and analog of a substratum, in the front face, the irregularity corresponding to the irregularity of the front face of a semiconductor substrate appears. For this reason, before forming a wiring pattern, it is necessary to carry out the flattening of the front face of a layer insulation layer.

[0005] There is the technique of applying this applied type insulator layer on an irregular semiconductor substrate as one of the technique of this surface flattening, using an applied type insulator layer as a layer insulation layer. It divides roughly into this applied type insulator layer, and there are a thing of an inorganic system and a thing of an organic system in it. Among these, after carrying out the spin application of the raw material liquid made to melt a silanol in water or alcohol on a semiconductor substrate as an applied type insulator layer of an inorganic system, what is called spin-on glass (Spin ON Glass, SOG) layer (henceforth "inorganic SOG layer") which can be made to vitrify easily is well known by performing heat treatment.

[0006] Since it is the layer insulation layer which can perform a surface flattening easily, this inorganic SOG layer has been used more widely than the former. However, this inorganic SOG layer has high hygroscopicity, and since many moisture is contained in the layer, when it uses as a layer insulation layer, the following problems produce it.

[0007] That is, in a manufacture of a semiconductor device, as shown in drawing 19, the spin application of the inorganic SOG layer 104 is carried out as a layer insulation layer on the whole surface so that the 1st wiring 103 formed through the layer insulation layer 102 on the semiconductor substrate 101 may be covered, and after making this inorganic SOG layer 104 vitrify by heat-treating, the contact hole 105 is formed in this inorganic SOG layer 104 by etching, for example. Next, although the 2nd wiring 106 which contacts the 1st wiring 103 through this contact hole 105 is formed by CVD or the sputtering method, poor embedding of the contact hole 105 (for example, occurrence of a void), peeling of the 2nd wiring 106 by aggravation of the adhesion to the inorganic SOG layer 104, etc. arise by applying heat in this case and emitting moisture to it from the inorganic SOG layer 104.

[0008] Inorganic SOG layer which raised hygroscopicity-proof is developed by including silicon (Si)-hydrogen (H) combination for the purpose of a resolution of these problems in recent years. After passing through various processes by inorganic SOG layer containing such Si-H coupling, it is important how it leaves Si-H coupling.

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Effect

[Effect of the Invention] As explained above, after forming the applied type insulator layer of the inorganic system containing Si-H coupling on a substrate according to this invention, To the front face of an applied type insulator layer, a pressure is O₂ in the ambient atmosphere 40Pa or less. By being made to perform processing which used ion as the main-reaction kind The surface layer of an applied type insulator layer can be made precise, after performing processing by medical fluids, such as heat treatment and an amine system organic solvent, behind for this reason, a decrement of Si-H coupling in an applied type insulator layer can be prevented, and the hygroscopicity-proof of an applied type insulator layer can be held highly.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, when according to this invention person's knowledge the inorganic SOG layer 104 containing Si-H coupling is heat-treated at the temperature of 500 degrees C or more or it processes with the medical fluids represented by the amine system organic solvent etc., such as a penetrant remover and a developer, the reaction from which Si-H coupling in the inorganic SOG layer 104 is cut is promoted by an operation of heat and the catalysis of a medical fluid. For this reason, Si-H coupling contained in the inorganic SOG layer 104 decreases, and hygroscopicity-proof gets worse as a result. [0010] That is, when the resist and developer which are used in case the contact hole 105 is formed, as shown in drawing 19, a penetrant remover, etc. contact the inorganic SOG layer 104, the reaction from which Si-H coupling is cut in this inorganic SOG layer 104 will arise, and the hygroscopicity-proof will get worse. For this reason, occurrence of the void in the interior of the contact hole 105, peeling of the 2nd wiring 106, etc. occurred, and the reliability of multilayer-interconnection structure was reduced.

[0011] The measurement result after washing according [accord / the measurement result after an application and heat treatment / drawing 20 / the drawing 20 and the drawing 21 show an example of the measurement result of the infrared absorption spectrum of the SOG layer 104, and / drawing 21] to an amine system organic penetrant remover is shown. Although the absorption peak which originates in the wave number [of 2300cm]-1 neighborhood at Si-H coupling is observed by the infrared absorption spectrum of the SOG layer 104 after an application and heat treatment as shown in the drawing 20 and the drawing 21 (drawing 20), the absorption peak resulting from this Si-H coupling is not observed by the infrared absorption spectrum of the SOG layer 104 after washing by the amine system organic penetrant remover (drawing 21). This shows that Si-H coupling in the SOG layer 104 has almost been cut by washing by the amine system organic penetrant remover.

[0012] Therefore, the purpose of this invention is to offer the formation technique of the insulator layer which can form the insulator layer by which high hygroscopicity-proof is held, after performing processing by medical fluids, such as heat treatment and an amine system organic solvent.

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MEANS

[Means for Solving the Problem] For the formation technique of the insulator layer according to this invention in order to attain the above-mentioned purpose, a pressure is O2 in the ambient atmosphere 40Pa or less to the front face of an application type insulator layer after forming the applied type insulator layer of the inorganic system containing Si-H coupling on a substrate. It is characterized by performing processing which used ion as the main-reaction kind.

[0014] A pressure is O2 in the ambient atmosphere 40Pa or less to the wall of a contact hole after forming a contact hole in an applied type insulator layer in the 1 operation gestalt of this invention. Processing which used ion as the main-reaction kind is performed.

[0015] It sets to this invention and is O2. At the pressure by which this exceeds 40Pa although the upper limit of the pressure of the ambient atmosphere of processing which used ion as the main-reaction kind is below 40Pa (**0.3Torr), it is O2. It is based on that a radical serves as a main-reaction kind and the effect of precise-izing of the surface layer of an applied type insulator layer becomes is hard to be acquired, and the grounds, -- a crack becomes easy to go into an applied type insulator layer

[0016] It is O2 in order to prevent nearly completely that hold the hygroscopicity-proof of an applied type insulator layer enough highly by precise-ization of a surface layer, and a crack etc. moreover enters in this invention. The pressure of the ambient atmosphere of processing which used ion as the main-reaction kind is suitably chosen as 6.6-13.3Pa (**0.05 - 0.1 Torr).

[0017] It sets to this invention and is O2. In processing which used ion as the main-reaction kind, it is the so-called hollow cathode (hollow cathode) suitably. The ashing equipment of type is used. For a parvus reason, the big discharge current flows [an electric discharge impedance] with this hollow cathode type ashing equipment. That is, the density of a plasma is very high and it is a lot of O2 on the front face of a processed substrate. Ion carries out incidence. In this case, these O2 Since the energy of ion is low, only the surface layer of an applied type insulator layer is made precise.

[0018] It sets to this invention and is O2. Compared with the ashing equipment of a hollow cathode type [processing / which used ion as the main-reaction kind], it is O2. Although ion density is generally low, you may use parallel monotonous type reactive-ion-etching (RIE) equipment.

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OPERATION

[Function] A pressure is O₂ in the ambient atmosphere 40Pa or less to the front face of the application type insulator layer after forming the applied type insulator layer containing Si-H coupling on a substrate according to the formation technique of the insulator layer by this invention constituted as mentioned above. By being made to perform processing which used ion as the main-reaction kind, the surface layer of this applied type insulator layer can be made precise. For this reason, even if it performs processing by medical fluids, such as heat treatment and an amine system organic solvent, after that, the reaction from which Si-H coupling in an applied type insulator layer is cut can be suppressed, and a decrement of Si-H coupling can be prevented. By this, the hygroscopicity-proof of an applied type insulator layer can be held highly.

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EXAMPLE

[Example] Hereafter, it explains, referring to a drawing about the example of this invention. In addition, in the complete diagram of an example, the same sign is given to an identity or a corresponding fraction.

[0021] Drawing 1 - view 8 is the cross section showing the manufacture technique of the semiconductor device by the 1st example of this invention in the order of a process.

[0022] In the manufacture technique of the semiconductor device by this 1st example, first, as shown in drawing 1, the 1st wiring 3 is formed through the layer insulation layer 2 on a semiconductor substrate 1 like Si substrate in which elements (not shown), such as a transistor, were formed beforehand.

[0023] Next, after carrying out a spin application on the whole surface, using the inorganic SOG layer 4 containing Si-H coupling as a layer insulation layer so that the 1st wiring 3 may be covered as shown in drawing 2, this inorganic SOG layer 4 is made to vitrify by performing heat treatment. Temperature of this heat treatment is made into the about temperature from which Si-H coupling in the inorganic SOG layer 4 is not cut, for example, 400 degrees C.

[0024] Next, it is O₂ as shown in drawing 3. By performing ashing processing which used ion as the main-reaction kind, the surface layer of the inorganic SOG layer 4 is made precise ("x" is given to the fraction made precise by this ashing processing.). This ashing processing is O₂ by hollow cathode type ashing equipment. It carried out for 1 minute on flow rate 100SCCM, RF power 200W, and conditions with a pressure of 13.3Pa (**0.1Torr).

[0025] An example of the hollow cathode type ashing equipment used for drawing 9 in this 1st example is shown. In drawing 9, a sign 21 shows a vacuum housing. Evacuation is carried out by the evacuation system (not shown) connected to evacuation opening 21a, and this vacuum housing 21 is O₂ from gas inlet 21b to the interior. Gas introduces. In this vacuum housing 21, the hollow cathode 22 which consists of the top electrode 22b of the shape of bottom electrode 22a and a mesh which counters mutually and was established is installed. RF power is impressed to this hollow cathode 22. The processed substrate 23 is laid on bottom electrode 22a.

[0026] Next, as shown in drawing 4, the resist pattern 5 of a predetermined configuration is formed on the inorganic SOG layer 4 with lithography. In case this resist pattern 5 is formed, although the reaction from which a resist, a developer, water, etc. contact the front face of the inorganic SOG layer 4, and Si-H coupling is cut arises, since the surface layer of the inorganic SOG layer 4 is beforehand made precise by ashing processing as mentioned above, this reaction is suppressed, therefore the hygroscopicity-proof of the inorganic SOG layer 4 does not get worse.

[0027] Next, it is C₂F₆ considering the inorganic SOG layer 4 as reactant gas, using the resist pattern 5 as a mask, as shown in drawing 5. CHF₃ it etches by the used RIE method and the contact hole 6 is formed.

[0028] Next, it is O₂ by the hollow cathode type ashing equipment shown in drawing 9 like ****. While ashing processing which used ion as the main-reaction kind is performed and the resist pattern 5 is removed, the surface layer of the inorganic SOG layer 4 of the wall of the contact hole 6 is made precise. Then, it washes for the purpose of a resist residue, elimination of a polymer, etc. using the amine system organic solvent etc. At the time of this washing, although the amine system organic solvent etc. contacts the inorganic SOG layer 4 of the wall of the contact hole 6, since the surface layer of the inorganic SOG layer 4 of the wall of this contact hole 6 is beforehand made precise by ashing processing as mentioned above, the reaction from which Si-H coupling is cut is suppressed and hygroscopicity-proof does not get worse.

[0029] Next, as shown in drawing 8, the 2nd wiring 7 which contacts the 1st wiring 3 through the contact hole 6 is formed by CVD or the sputtering method. As mentioned above, although the case where heat is applied is most in case this 2nd wiring 7 is formed, since the hygroscopicity-proof of the inorganic SOG layer 4 is not getting worse, there is no exudation of gas which is represented by moisture from this inorganic SOG layer 4, and the failures in the interior of the contact hole 6, such as occurrence of a void and peeling of the 2nd wiring 7, are not produced.

[0030] Drawing 10, the drawing 11, and the drawing 12 show an example of the measurement result of the infrared absorption spectrum of the inorganic SOG layer 4, and show an application of the inorganic SOG layer 4 and the measurement result after heat treatment, the measurement result after ashing processing, and the measurement result after washing by the amine system organic penetrant remover, respectively.

[0031] As shown in drawing 10, the drawing 11, and the drawing 12, the absorption peak of the wave number [of 2300cm⁻¹]-1 neighborhood resulting from Si-H coupling is similarly observed in any after washing after an application and heat treatment of the inorganic SOG layer 4, and ashing processing and by the amine system organic penetrant remover. This shows that Si-H coupling in the inorganic SOG layer 4 is not decreasing, after passing through these processes.

[0032] As mentioned above, it is O₂ in the ambient atmosphere whose pressure is 40Pa or less, for example, 13.3Pa, at the wall of the front face of the inorganic SOG layer 4 containing Si-H coupling, and the contact hole 6 according to this 1st example. Since ashing processing which used ion as the main-reaction kind is performed, the surface layer of this inorganic SOG layer 4 and the surface layer of the inorganic SOG layer 4 of the wall of the contact hole 6 can be made precise. For this reason, even if it performs processing by medical fluids, such as heat treatment and an amine system organic solvent, behind, it can prevent Si-H coupling in the inorganic SOG layer 4 being cut, and decreasing, and the hygroscopicity-proof of this inorganic SOG layer 4 can be held highly. By this, occurrence of the void in the interior of the contact hole 6 resulting from exudation of gas, such as moisture from this inorganic SOG layer 4, peeling of the 2nd wiring 7, etc. can be prevented, and reliable multilayer-interconnection structure can be realized.

[0033] Next, the 2nd example of this invention is explained.

[0034] Drawing 13 - view 18 is the cross section showing the manufacture technique of the semiconductor device by the 2nd example of this invention in the order of a process.

[0035] In the manufacture technique of the semiconductor device by this 2nd example, first, as shown in drawing 13, the layer insulation layer 8 is formed like the manufacture technique of the semiconductor device by the 1st example, so that the 1st wiring 3 formed through the layer insulation layer 2 on the semiconductor substrate 1 may be covered. It is SiO₂ formed as this layer insulation layer 8 by the plasma CVD method which made reactant gas TEOS (Si₄ (OC₂ H₅)). SiO₂ formed by the layer and the plasma CVD method which made the silane (SiH₄) reactant gas A layer is used suitably. This layer insulation layer 8 protects the below-mentioned inorganic SOG layer 4 from a medical fluid etc., or is formed of the ground for aiming at enhancement of adhesion to the substratum of this inorganic SOG layer 4 etc.

[0036] Next, as shown in drawing 14, after carrying out the spin application of the inorganic SOG layer 4 containing Si-H coupling on the whole surface, this inorganic SOG layer 4 is made to vitrify by performing heat treatment. Next, the layer insulation layer 9 is formed on this inorganic SOG layer 4. It is SiO₂ formed like the layer insulation layer 8 as this layer insulation layer 9 by the plasma CVD method which made reactant gas TEOS (Si₄ (OC₂ H₅)). A layer and SiH₄ SiO₂ formed by the plasma CVD method made into reactant gas A layer is used suitably. This layer insulation layer 8 protects the below-mentioned inorganic SOG layer 4 from a medical fluid etc., or is formed of the ground for aiming at enhancement of adhesion to the substratum of the 2nd below-mentioned wiring 7 etc.

[0037] Next, as shown in drawing 15, the resist pattern 5 of a predetermined configuration is formed on the layer insulation layer 9 with lithography. In this case, since the layer insulation layers 8 and 9 formed in the upper and lower sides of the inorganic SOG layer 4 of CVD exist, it can avoid that the medical fluids which trigger the reaction from which Si-H coupling is cut, such as a resist and a developer, contact the inorganic SOG layer 4, therefore the hygroscopicity-proof of the inorganic SOG layer 4 does not get worse.

[0038] Next, it is C₂ F₆ considering the layer insulation layer 9, the inorganic SOG layer 4, and the layer insulation layer 8 as reactant gas, using the resist pattern 5 as a mask, as shown in drawing 16. CHF₃ It etches one by one by the used RIE method, and the contact hole 6 is formed.

[0039] Next, it is O₂ by the hollow cathode type ashing equipment shown in drawing 9 like the 1st example as shown in drawing 17. While ashing processing which used ion as the main-reaction kind is performed and the resist pattern 5 is removed, the surface layer of the inorganic SOG layer 4 of the wall of the contact hole 6 is made precise ("x" is given to the fraction made precise by this ashing processing.). This ashing processing is O₂. It carried out for 1 minute on flow rate 100SCCM, RF power 200W, and conditions with a pressure of 13.3Pa (*0.1Torr). Then, it washes for the purpose of elimination of a resist residue or a polymer using penetrant removers, such as an amine system organic solvent. At the time of this washing, even if a penetrant remover contacts the inorganic SOG layer 4 of the wall of the contact hole 6, since the surface layer of the inorganic SOG layer 4 of this wall is beforehand made precise by ashing processing as mentioned above, the reaction from which Si-H coupling is cut is suppressed and the hygroscopicity-proof of the inorganic SOG layer 4 does not get worse.

[0040] Next, as shown in drawing 18, the 2nd wiring 7 which contacts the 1st wiring 3 through the contact hole 6 is formed by CVD or the sputtering method. As mentioned above, although the case where an elevated temperature is applied is most in case this 2nd wiring 7 is formed, since the hygroscopicity-proof of the inorganic SOG layer 4 is not getting worse, there is no exudation of gas which is represented by moisture from the inorganic SOG layer 4, therefore the failures in the interior of the contact hole 6, such as occurrence of a void and peeling of the 2nd wiring 7, are not produced.

[0041] As mentioned above, according to this 2nd example, the aggravation of hygroscopicity-proof by being able to avoid that medical fluids, such as a resist and a developer, contact the inorganic SOG layer 4 in a next process, therefore these medical fluids contacting this inorganic SOG layer 4 can be prevented by forming the layer insulation layers 8 and 9 in the upper and lower sides of the inorganic SOG layer 4 by CVD. Moreover, it is O₂ to the wall of this contact hole 6 after forming the contact hole 6 in the inorganic SOG layer 4 like the 1st example. Since ashing processing which used ion as the main-reaction kind is performed, the surface layer of the inorganic SOG layer 4 of the wall of this contact hole 6 can be made precise, and the hygroscopicity-proof of the inorganic SOG layer 4 can be held highly. By this, occurrence of the void in the interior of the contact hole 6 resulting from exudation of gas, such as moisture from this inorganic SOG layer 4, peeling of the 2nd wiring 7, etc. can be prevented. Reliable multilayer-interconnection structure is realizable with the above.

[0042] As mentioned above, although the example of this invention was explained concretely, this invention is not limited to an above-mentioned example, and various kinds of deformation based on the technical thought of this invention is possible for it.

[0043] For example, in the 1st above-mentioned example and the 2nd example, although the inorganic SOG layer 4 containing

- Si-H coupling is used as an applied type insulator layer of the inorganic system containing Si-H coupling, as long as it is an inorganic system insulator layer containing Si-H coupling, you may use things other than inorganic SOG layer 4.

[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is a cross section for explaining the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 2] It is a cross section for explaining the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 3] It is a cross section for explaining the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 4] It is a cross section for explaining the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 5] It is a cross section for explaining the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 6] It is a cross section for explaining the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 7] It is a cross section for explaining the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 8] It is a cross section for explaining the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 9] It is the abbreviation diagram showing an example of the hollow cathode type ashing equipment used for ashing processing in the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 10] It is the graph which shows an example of the measurement result of the infrared absorption spectrum of inorganic SOG layer after performing application and heat treatment in the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 11] It is the graph which shows an example of the measurement result of the infrared absorption spectrum of inorganic SOG layer after performing ashing processing in the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 12] It is the graph which shows an example of the measurement result of the infrared absorption spectrum of inorganic SOG layer after performing washing by the amine system organic penetrant remover in the manufacture technique of the semiconductor device by the 1st example of this invention.

[Drawing 13] It is a cross section for explaining the manufacture technique of the semiconductor device by the 2nd example of this invention.

[Drawing 14] It is a cross section for explaining the manufacture technique of the semiconductor device by the 2nd example of this invention.

[Drawing 15] It is a cross section for explaining the manufacture technique of the semiconductor device by the 2nd example of this invention.

[Drawing 16] It is a cross section for explaining the manufacture technique of the semiconductor device by the 2nd example of this invention.

[Drawing 17] It is a cross section for explaining the manufacture technique of the semiconductor device by the 2nd example of this invention.

[Drawing 18] It is a cross section for explaining the manufacture technique of the semiconductor device by the 2nd example of this invention.

[Drawing 19] It is a cross section for explaining the manufacture technique of the conventional semiconductor device.

[Drawing 20] It is the graph which shows an example of the measurement result of the infrared absorption spectrum of inorganic SOG layer after performing application and heat treatment in the manufacture technique of the conventional semiconductor device.

[Drawing 21] It is the graph which shows an example of the measurement result of the infrared absorption spectrum of inorganic SOG layer after performing washing by the amine system organic penetrant remover in the manufacture technique of the conventional semiconductor device.

[Description of Notations]

- 1 Semiconductor Substrate
- 2, 8, 9 Layer insulation layer
- 3 1st Wiring
- 4 Inorganic SOG Layer
- 6 Contact Hole
- 7 2nd Wiring

[Translation done.]